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Environmental tobacco smoke awareness and exposure: impact of a statewide clean indoor air law and the report of the US Environmental Protection Agency

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Abstract

Objective **– To determine whether a statewide clean indoor air law and the report of the US Environmental Protection Agency (EPA) affected awareness of and exposure to environmental tobacco smoke.**

Design **– Cross sectional telephone survey.**

Setting **– Missouri, United States, 1990–1993.**

Participants **– Population based sample of Missouri residents aged ⩾ 18 years (n = 6052).**

Main outcome measures **– A special series of questions was added to ascertain environmental tobacco smoke awareness, workplace and home exposure, and actions to reduce restaurant exposure.**

Results **– Awareness of the state law increased following enactment ($p < 0.001$). Workplace exposure varied between the pre- and the post-state law periods (44.2% *v* 34.7%; $p < 0.001$). A slight decline in workplace environmental tobacco smoke exposure before the state law was enacted accelerated after it was enacted. The report of the EPA did not appear to increase this trend. Self reported home exposure to environmental tobacco smoke did not vary significantly over the study period. The percentage of non-smokers asking to be seated in the non-smoking section of a restaurant increased in the post-state law period.**

Conclusions **– A statewide clean indoor air law is beneficial in reducing non-smokers' exposure to environmental tobacco smoke. Despite improvements, non-smoker exposure to environmental tobacco smoke remains widespread, and more comprehensive measures are necessary.**

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Keywords: exposure; public policy; survey; tobacco smoke pollution

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Introduction

The detrimental health effects of exposure to environmental tobacco smoke are now well established.[1–4] Environmental tobacco smoke is known to cause lung cancer in non-smokers and lower respiratory tract infections in infants and children,[1–4] and has been linked with heart disease[5] and sudden infant death syndrome.[6]

In "Healthy people 2000: National health promotion and disease prevention objectives"[7] – the nation's public health goals – it was proposed that comprehensive clean indoor air laws strictly limiting smoking in public places and worksites should be enacted in all 50 states. A "comprehensive" law was defined as one including private and public workplaces.[7] As of August 1994, 41 states had enacted laws restricting smoking in at least one public place, and 16 states had enacted comprehensive laws affecting workplaces.[8] In addition, hundreds of local jurisdictions have enacted regulations to limit public smoking.[8–11]

Despite the widespread implementation of public smoking restrictions, few data exist on the effectiveness of these restrictions in reducing environmental tobacco smoke exposure among non-smokers. A recent study from California suggested that strong local smoking ordinances reduce non-smokers' workplace exposure to tobacco smoke.[12] However, no study to date has examined whether statewide smoking restrictions affect environmental tobacco smoke exposure on a population basis. Evaluation of the effects of public smoking restrictions has been cited as an important public health objective.[10,13,14]

There were no statewide restrictions on public smoking in Missouri until 1992. However, during the 1992 Missouri General Session, statewide clean indoor air legislation was enacted that restricted smoking in workplaces, public buildings, and restaurants.[15]

In addition to tobacco control advances at the state level, the report of the US Environmental Protection Agency (EPA) was released in January 1993.[4,16] The EPA report designated environmental tobacco smoke as a group A (known human) carcinogen.[4] By placing environmental tobacco smoke in the same category with a small group of known carcinogens (for example, asbestos, benzene, radon), it became subject to similar regulatory

standards and legal precedents.[16] This designation has stimulated further regulation of smoking in public places.[17-19]

Using population based secular data on environmental tobacco smoke awareness and exposure, we examined changes over time in relation to two major events: the recent passage of a statewide clean indoor air law in Missouri[15] and the recent release of the report of the US EPA.[4]

Methods

MISSOURI CLEAN INDOOR AIR LAW

The Missouri clean indoor air law was passed by the Missouri General Assembly in May 1992 and became effective on August 28, 1992 (Missouri revised statutes 191.765–191.773). This law stipulates that a person cannot smoke in public places (including workplaces) or in public meetings except in designated smoking areas.[20] A proprietor may set aside up to 30% of the total area as a smoking area, although it is not mandatory to establish a smoking area.[20] Certain public places are exempted (bars, taverns, bowling alleys, billiard parlours, tobacco stores, and restaurants that seat fewer than 50 persons). The Missouri law is more restrictive than the majority of other state clean indoor air laws currently in effect.[8]

THE EPA REPORT

The release of the US EPA report on January 7, 1993 provided further support for policy actions to reduce exposure to environmental tobacco smoke.[17-19] The EPA report quantified the health effects of environmental tobacco smoke and estimated that it causes: (1) approximately 3000 US lung cancer deaths annually among non-smokers, through its action as a known human carcinogen; (2) 150000 to 300000 annual cases of respiratory conditions among children (for example, bronchitis and pneumonia); (3) middle ear infections in children; and (4) 200000 to 1000000 annual cases of asthmatic episodes in children.[4] Because of the designation of environmental tobacco smoke as a group A carcinogen, the EPA report shifted the debate from an issue between smokers and non-smokers to environmental tobacco smoke as an environmental agent in the workplace causing disease.[16]

ENVIRONMENTAL TOBACCO SMOKE SURVEY DATA

Population based exposure to environmental tobacco smoke was ascertained through the behavioural risk factor surveillance system (BRFSS), which was developed in 1981 by the US Centers for Disease Control and Prevention (CDC). The BRFSS provides a flexible, state health agency based surveillance system to assist in planning, implementing, and evaluating health promotion and disease prevention programmes.[21,22]

We shall briefly review survey methods, which have been discussed in detail elsewhere.[21-23] Using random digit dialling,[24] a random sample was selected from Missouri's non-institutionalised adult population (aged $\geqslant$ 18 years) who had telephones. The survey was administered by trained interviewers during a two week period, beginning on the second Wednesday of each month, between January 1990 and December 1993. During each month, approximately 126 interviews were conducted – a total of 6052 interviews over the entire study period. Among eligible respondents (that is, working phones, non-business phone extensions), the response rate was 73%. Our sample was generally representative of the overall Missouri population,[25] although it slightly underrepresented younger persons, males, blacks, and persons with less education (table 1).

The BRFSS instrument consisted of standardised questions developed by CDC, plus state-added questions on various topics. In 1990, and again in 1991 and 1992, the Missouri Department of Health added a series of questions (based mainly on earlier surveys[27-31]) to ascertain beliefs about environmental tobacco smoke, exposure to tobacco smoke, and actions taken to reduce exposure.

STATISTICAL ANALYSES

Following completion of each month's interviewing cycle, BRFSS data were edited and weighted to adjust for the probability of selection, and for the age, race, and gender distribution of the population.[25,32,33] Our previous work[30] has shown that sociodemographic variables may affect behaviours to reduce exposure to environmental tobacco smoke.

To assess changes over time, we primarily analysed four special questions (table 2). These questions measured awareness of the state clean indoor air law, self reported tobacco smoke exposure at work and in the home, and action to reduce environmental tobacco smoke exposure in restaurants by asking for non-smoking seating. For analyses of workplace tobacco smoke exposure, respondents who were unemployed or retired were excluded. Although the state clean indoor air law was not anticipated to affect home tobacco smoke exposure, this variable was analysed for comparison with variables more directly affected by new ordinances and regulations (for example, workplace exposure).

We limited our analyses to never-smokers and former smokers, who were defined as "non-smokers" for the study. Smoking status was ascertained through standard questions: "Have you smoked at least 100 cigarettes in your lifetime?" and "Do you smoke cigarettes now?"

For each of the questions of interest, we calculated weighted, two month averages and weighted prevalence measures for time periods of interest before and after the state law and release of the EPA report. We used the gaussian z statistic to compare prevalence rates between time periods.[33]

For regression analyses, a line of best fit using the least squares techniques was constructed for variables on exposure and actions based on the two month averages. For each

Table 1 Respondent characteristics by sociodemographic grouping, Missouri, 1990–1993

Characteristic	Number	Sample %	Census %[a] (Missouri/US)
Age (years)			
18–34	1921	31.8	35.9/37.7
35–54	2027	33.5	33.1/34.1
55+	2069	34.2	30.9/28.3
Unknown/refused	35	0.5	
Gender			
Female	3605	59.6	52.9/52.2
Male	2447	40.4	47.1/47.8
Race			
White	5435	89.8	88.8/82.2
African American	501	8.3	9.7/11.0
Other	116	1.9	1.5/6.8
Education level			
Less than high school graduate	1097	18.1	25.5/24.6
High school or technical school graduate	3694	61.0	58.1/50.9
College graduate	1253	20.7	16.4/24.6
Unknown/refused	8	0.1	
Smoking status			
Never smoked	3039	50.2	50.2[b]
Former smoker	1451	24.0	24.1
Current smoker	1547	25.6	25.7
Unknown/refused	15	0.2	

[a] Based on the 1990 US Census population aged 18 years and older.[25]
[b] US smoking rates for 1991.[26]

Table 2 Questions used to measure awareness, exposure, and actions to reduce environmental tobacco smoke (ETS) exposure, and beliefs about ETS, Missouri, 1990–1993

Category	Question
Awareness of state law	Is there a state law in Missouri that limits smoking in public places such as grocery stores, restaurants, and shopping malls?
Exposure to ETS	When you are at work, are you exposed to the smoke from other people's cigarettes, pipes, or cigars?
	When you are at home, are you exposed to the smoke from other people's cigarettes, pipes, or cigars?
Actions to reduce ETS	In the past year, have you asked to be seated in the nonsmoking area of a restaurant?

Table 3 Comparison of environmental tobacco smoke (ETS) awareness, exposure, and action during three time periods, Missouri, 1990–1993

Variable	Percentage (±95% confidence interval)			p Value for difference[a]		
	Period (1)[b]	Period (2)[c]	Period (3)[d]	(1) (2)	(1) (3)	(2) (3)
Aware of state law restricting ETS	42.6±3.7	56.3±5.4	48.9±3.2	< 0.001	0.013	0.021
Exposed–workplace	44.2±2.6	33.2±6.3	34.7±4.1	0.01	< 0.001	> 0.10
Exposed–home	18.5±1.6	14.3±3.8	16.8±2.4	0.05	> 0.10	> 0.10
Asked for non-smoking in restaurant	76.4±2.2	84.2±3.7	82.2±2.5	< 0.001	0.001	> 0.10

[a] Two tailed.
[b] Awareness of law restricting ETS: January 1992–August 1992; exposed in workplace or home: January 1990–August 1992; asked for non-smoking area in restaurant: January 1991–August 1992.
[c] For all variables: September 1992–December 1992.
[d] For all variables: January 1993–December 1993.

linear model, R^2 values, slope estimates, and standard errors of slopes were calculated. We used Student's t test[34] to determine whether the slope was significantly different from zero.

To assess the possible confounding effects of local (that is, city or county) ordinances on environmental tobacco smoke exposure, we reran all analyses excluding counties for which $\geqslant 50\%$ of the population was covered by a comprehensive smoking control ordinance (that is, restricting smoking in workplaces, restaurants, and other public places) before the beginning of the study.[11] In Missouri, only four communities had smoking control ordinances that included workplace restrictions over the entire study period.[11] These analyses had minimal impact on the results based on the full dataset; therefore, only results based on the complete dataset are presented.

Results

Table 3 presents awareness, exposure to environmental tobacco smoke, and action to reduce restaurant tobacco smoke exposure for three periods of interest: (1) before the state law; (2) after the state law but before EPA; and (3) after EPA. Awareness of the state law increased following the effective date of the law ($p < 0.001$). During the post-EPA period (January 1993 to December 1993), awareness of the state law was 48.9%. Awareness of the state law was significantly higher in period 2 than in period 3. Although not shown in the table, the "don't know" response was common during the post-state law period (32.1% of respondents).

Self reported exposure to environmental tobacco smoke in the workplace decreased substantially between period 1 and subsequent periods (table 3). Over the entire study period,

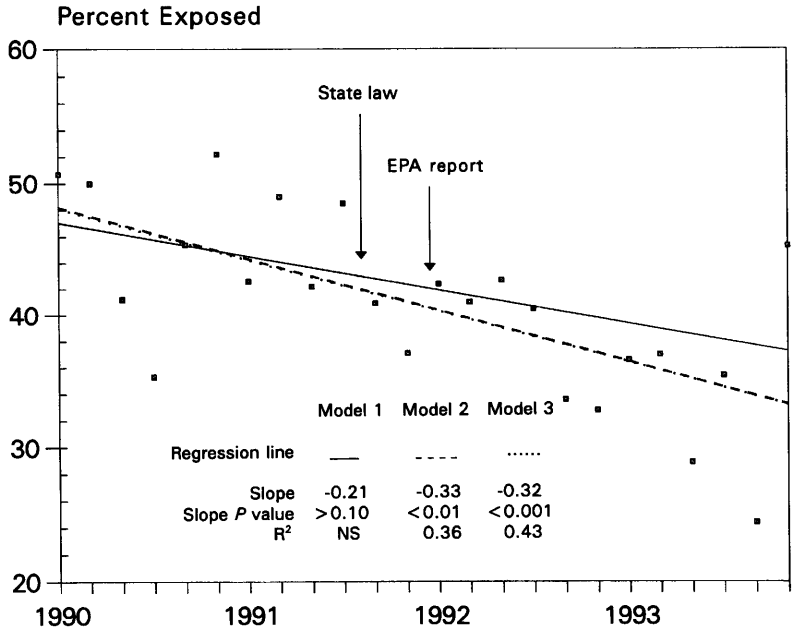

Figure 1 Weighted prevalence of self-reported exposure to environmental tobacco smoke in the workplace, Missouri, 1990–1993. Model 1 = January 1990–August 1992; model 2 = January 1990–December 1992; model 3 = January 1990–December 1993. EPA, Environmental Protection Agency.

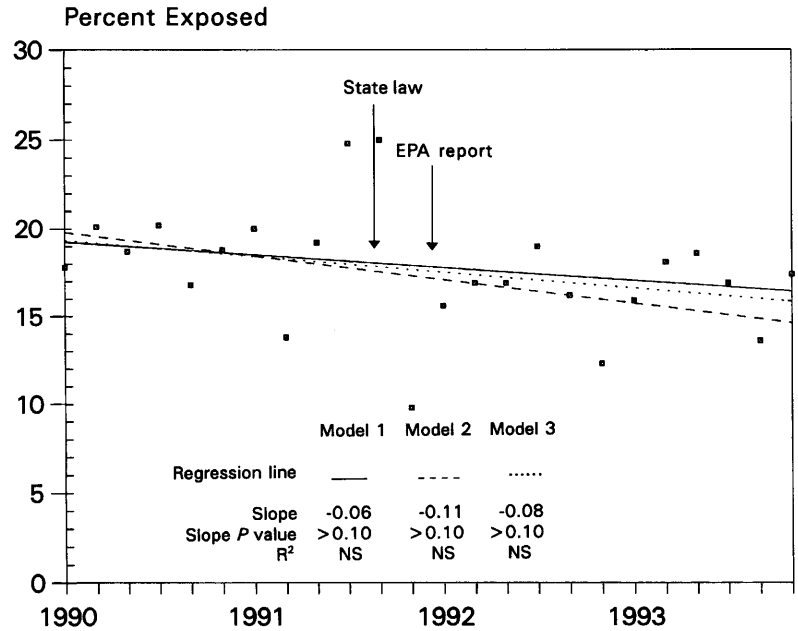

Figure 2 Weighted prevalence of self reported exposure to environmental tobacco smoke in the home, Missouri, 1990–1993. Model 1 = January 1990–August 1992; model 2 = January 1990–December 1992; model 3 = January 1990–December 1993. EPA, Environmental Protection Agency.

non-smokers' exposure in the workplace was 40.7% (95% confidence interval (CI) = 38.6–42.9). Exposure varied 10 percentage points between periods 1 and 3 (44.2% *v* 34.7%; $p < 0.001$). Exposure to environmental tobacco smoke in the home for the entire study period was 17.8% (95% CI = 16.5–19.0). Self reported home exposure did not vary between periods 1 and 3 ($p > 0.10$). Over the entire study period, 79.2% (95% CI = 77.7–80.8) of non-smokers had asked to be seated in the non-smoking section of a restaurant within the past year. The percentage asking for a non-smoking section ranged from 76.4% in period 1 to 82.2% in period 3 ($p < 0.001$). None of the factors on exposure or non-smoking preference in restaurants varied significantly between periods 2 and 3.

A non-significant decline in workplace exposure to environmental tobacco smoke was occurring before enactment of the state clean indoor air law (model 1 in figure 1). When the model included the period August 1992 to December 1992 (model 2) or the period August 1992 to December 1993 (model 3), the slope values were larger and identical. Therefore, the regression lines for models 2 and 3 overlap. The R^2 value was largest for model 3 ($R^2 = 0.43$), suggesting the best linear fit for this model. The R^2 value is not shown for model 1 because the slope estimate was not significantly different from 0.

Among the three regression models predicting home environmental tobacco smoke exposure, the slope estimate was largest for model 2 ($\beta = -0.11$) (figure 2). None of the three models resulted in a statistically significant slope estimate, suggesting that home environmental tobacco smoke exposure did not decline significantly over the study period. No R^2 values are presented because of the non-significant slope estimates.

Increasing preference for restaurant non-smoking areas was identified in models 2 and 3, with a larger slope in model 2 ($\beta = 0.38$) (figure 3). The R^2 value was largest for model 3 ($R^2 = 0.38$).

Discussion

These population based survey data are among the first published evidence of the effects of a statewide clean indoor air law and the report of the US EPA on environmental tobacco smoke awareness, exposure, and action to reduce exposure in restaurants.

We documented increasing awareness of smoking restrictions, ranging from 42.6% before enactment of the law to 56.3% in the four month period after the law became effective. However, in the most recent time period (period 3), more than half of non-smoking respondents were unaware of the state clean indoor air law, indicating the need for substantial public education efforts. Intense media coverage[35–39] and public education efforts[20] around the effective date of the state law may have increased awareness for a period of several months. While one might expect awareness to increase around the time of passage of the law (May 1992), media coverage around the effective date appears to have had a larger effect on public awareness.

Exposure to tobacco smoke in the workplace was significantly reduced in the period following enactment of the state clean indoor air law. However, even in the most recent time period (period 3), over one third of respondents reported exposure to tobacco smoke in the workplace. Earlier data from California suggest that adequate protection of non-smokers from tobacco smoke requires a total ban on workplace smoking,[40] such as those recently enacted in California through

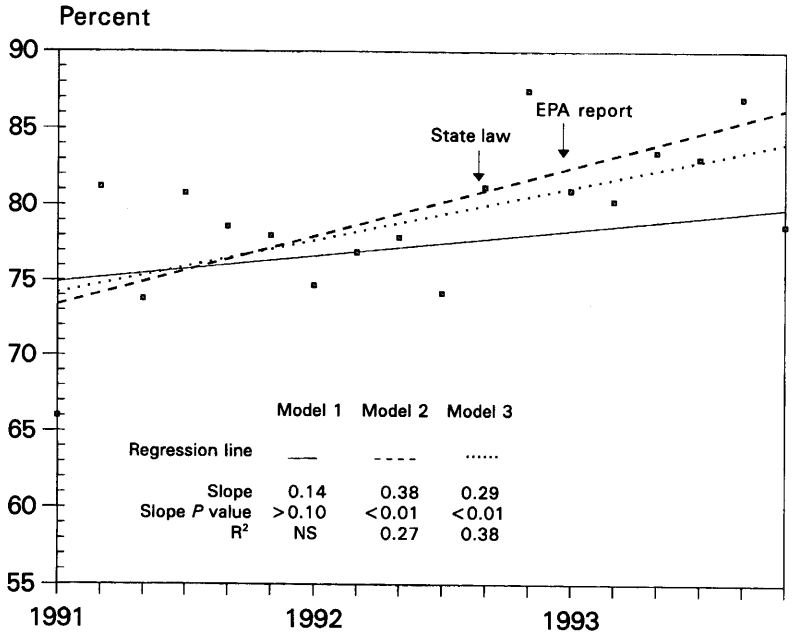

Figure 3 Weighted prevalence of asking to be seated in a non-smoking area of a restaurant, Missouri, 1991–1993. Model 1 = January 1991–August 1992; model 2 = January 1991–December 1992; model 3 = January 1991–December 1993. EPA, Environmental Protection Agency.

legislation[41] and in Maryland through state regulation.[42] Action to reduce exposure in restaurants, through asking for seating in a non-smoking section, also increased significantly following the policy initiatives.

Few data are available with which to compare our findings. Point-in-time survey data from California[12] documented the effects of strong *local* tobacco control ordinances. Pierce *et al*[12] defined workplace exposure as an affirmative response to: "During the past two weeks has anyone smoked in the area in which you work?" Using this question, non-smoker environmental tobacco smoke exposure at work varied from 24.5% to 34.8%, depending on the presence of local smoking control ordinances. Our study found that workplace exposure varied from 44.2% in period 1 to 34.7% in period 3. The variations between Missouri and California data are not unexpected considering the 1989 enactment of California Proposition 99, with its aggressive antismoking media campaign[43,44] Also, local smoking control restrictions are common in California (190 local smoking ordinances in 1990 including 175 with workplace restrictions).[11,12] This compares with seven local smoking ordinances in Missouri in 1990, including four with workplace restrictions.[11] The presence of local ordinances in Missouri did not appear to have had a significant impact on overall exposure to environmental tobacco smoke, because exclusion of localities with comprehensive ordinances did not affect our findings.

Our data showed no significant decline in non-smokers' exposure to tobacco smoke in the home. Because the Missouri law does not affect private residences, we did not anticipate a decline in home tobacco smoke exposure over the study period. However, tobacco smoke exposure in the home is a health hazard,[4] particularly for children.[45,46] Additional efforts to educate the public about the health effects of environmental tobacco smoke, such as the current campaign from the US Centers for Disease Control and Prevention (ie, "Secondhand Smoke: We're All At Risk"),[47] are warranted.

The primary goal of the *Healthy people 2000* objective calling for comprehensive state smoking laws is to protect non-smokers from the health hazards of environmental tobacco smoke exposure.[7] An additional benefit from clean indoor air regulations may be a reduction in smoking prevalence among workers and the general public. For example, in a recent multivariate analysis, Emont *et al*[48] found that moderate or extensive clean indoor air laws were associated with a lower smoking rate and a higher proportion of quitters. Rigotti and Pashos[9] found an association between local smoking restrictions and smoking prevalence. Because our study involved statewide restrictions and we lack a comparison group, we are unable to examine the possible effect of the statewide law on smoking prevalence.

The limitations of our study should be noted. We relied on self reported telephone survey data and had no comprehensive information on the reliability and validity of the BRFSS data during the entire study period. However, previous studies[31,49,50] have shown relatively high accuracy of BRFSS-collected data on reported cardiovascular risk factors and on demographics. In addition, a 1993 test-retest study of the Missouri BRFSS found relatively high reliability for questions involving individual actions to reduce exposure to environmental tobacco smoke (κ values 0.62 to 0.82).[31] Since BRFSS relies on telephone interviews, potential exists for response bias because of lack of phone coverage among certain sociodemographic groups.[51]

Because of the limited number of questions available for analysis and the self reported nature of the information, we were unable to differentiate some important measurement issues. For example, we cannot quantify the frequency of exposure to high levels of environmental tobacco smoke, which may be important in determining lung cancer risk in non-smokers.[52] In addition, comparisons of ambient and biological measurements with self reported data have suggested discrepancies.[53,54]

There also may be other intervening variables that may account for some of the changes in environmental tobacco smoke exposure observed over time. For example, Missouri is one of 17 states participating in the American Stop Smoking Intervention Study (Project ASSIST).[10,55] The Missouri ASSIST program has selected environmental tobacco smoke exposure as one of its priorities.[56] However, because full scale interventions did not begin until fall 1993, it is unlikely that Missouri ASSIST affected our findings. It is also possible that more time is needed to evaluate the effects of the EPA report, since further action based on the report (for example, regulation of environmental tobacco smoke by

the Occupational Safety and Health Administration) may take several years to implement.

In summary, our findings indicate that a statewide clean indoor air law is beneficial in reducing non-smokers' exposure to environmental tobacco smoke in the workplace. Over the study period, the report of the US EPA does not appear to have accelerated significantly the rate of decline in non-smokers' exposure to environmental tobacco smoke in the workplace. Our study, coupled with earlier work from California,[12,57] indicates that comprehensive state clean indoor air laws and regulations should be used in combination with local ordinances to control environmental tobacco smoke exposure on a population basis. In addition, this study and earlier studies[30,58] show the usefulness and flexibility of the BRFSS, the world's largest health surveillance system, for evaluation of policy related disease prevention initiatives.

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